Numerical Weather Prediction

The 2002/03 Data Assimilation Upgrades in the UK Mesoscale Model

Forecasting Research Technical Report No. 435

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by

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February 6th 2004

Abstract

Following the implementation of the first New Dynamics (ND) version of the UK Mesoscale Model in August 2002, two upgrades to the data assimilation took place in December 2002 and March 2003. These upgrades aimed to deal with some re-tuning issues for ND and also to introduce enhancements to the observation input.

In the December 2002 upgrade, the two main components were new forecast error covariances and a reduced weighting for cloud data. Objective verification of case studies showed overall a 2% increase in the estimate of the UK NWP index, with improvement in all 5 components. In particular, precipitation skill was improved for all thresholds and forecast ranges.

The package introduced in March 2003 had several components, of which the most significant were retuned rainfall assimilation, and the introduction of AMSU data. Overall objective verification of the case studies gave a 0.3% increase in the estimate of the 5-component UK index for the trial, with a larger benefit in the early part of the rainfall forecast. The objective verification of the real-time trial gave a trial 5-component UK index that was +1.4% with respect to the control run. In subjective assessment of the real-time trial, the signal was broadly neutral but with a slight advantage to the trial in precipitation.

1. Introduction

In August 2002 the Met Office implemented a new Unified Model which consisted of a reformulation of the dynamical core and a revised physics package (Wilson et al., 2004). Data assimilation systems, to perform well, must be tuned according to the characteristics of the forecast model. The package of changes introduced operationally in December 2002 was primarily a retuning of the data assimilation following introduction of the new UM. The second package of changes, March 2003, was a further tuning and the introduction of AMSU data. Both changes were tested on case studies and in real-time trials. The packages and results from the testing are presented here.

2. December 2002 Upgrade

This was the first attempt to tune the assimilation system following the model change. The package had two components: revised background error statistics for 3D-Var and reduced weight for MOPS cloud within the AC scheme. These were tested together on 12 case studies covering the required variety of synoptic types. Each case study comprised 24 hours of assimilation cycle and two 36-hour forecasts. The package was also tested in a 'real-time' system running parallel to the operational system.

2.1 Components of package

New background error covariances

The new covariances were based on 8 months of accumulated T+24 - T+12 forecast differences. The statistics looked less noisy than the operational covariances, which were based on a much shorter period of data. Several scaling parameters were also revised. The net effect was that the specified background errors were smaller than previously, but more in line with 'observed' forecast differences from the NMC method, and with what is used in the global model. The effect on the analysis was to draw slightly less to observations and stay slightly closer to the model background. The new statistics also meant that the Var descent algorithm converged faster than before.

Retuned MOPS Cloud in AC scheme

Testing revealed that for New Dynamics we were giving too much weight to MOPS cloud data within the AC scheme. The data was improving model forecasts of cloud cover but at the expense of precipitation scores. Halving the weight continued to give benefit to cloud but with negligible detriment to precipitation.

2.2 Case Studies

Twelve cases were chosen, covering the required range of synoptic types. Each was run with twelve hours of assimilation, then a 36-hour forecast, and a further 12 hours of assimilation with another 36-hour forecast.

04/08/01 12Z, 05/08/01 00Z organised convection (Summer)
25/08/01 12Z, 26/08/01 00Z clear Summer day
22/09/01 12Z, 23/09/01 00Z radiation fog
07/10/01 00Z, 07/10/01 12Z land gales
14/10/01 00Z, 14/10/01 12Z radiation fog
23/10/01 12Z, 24/10/01 00Z organised convection (Winter)
28/12/01 00Z, 28/12/01 12Z mixed snow and rain
31/12/01 00Z, 31/12/01 12Z clear Winter night
25/01/02 00Z, 25/01/02 12Z air mass (active) front
27/01/02 00Z, 27/01/02 12Z stratus
03/03/02 00Z, 03/03/02 12Z stratocumulus
02/05/02 00Z, 02/05/02 12Z convection - diurnal, local heating, land-based

2.2.1 Subjective Assessment

Assessment was made comparing the control and the trial forecasts for all the case study dates and times and all from T+0 to T+36 for the following fields:

Precipitation, High, medium and low layered cloud, Pressure at mean sea level, 1.5m temperature, Fog probability

All but two of the runs showed no significant differences between the two outputs. 12Z 3rd March 2002 was a stratocumulus case in association with a weak ridge of high pressure. The trial had more extensive low cloud than the control in most frames over central and southern England. This led to the overnight 1.5m temperature forecast from 12Z being between 2 and 4 degrees Celsius warmer in the trial (Figure 2.2.1a) than in the control (Figure 2.2.1b) in this area from T+9 through to T+36 inclusive. Additionally, at T+21 (09Z) the fog probability was lower on the trial run over much of central southern England and London. These differences all verified better against synoptic observations.

The other case to show significant differences was the mixed rain and snow event on 28th December 2001. This was in association with a frontal wave running east-southeast across SW England, giving some snowfall on its northern side inland. The assimilation cycle started at 12Z on the 27th with 36-hour forecasts from 00Z and 12Z on the 28th. At midday on the 29th there were areas of precipitation over London and Cornwall. Both trial and control extended the area over Cornwall too far north, as shown in Figure 2.2.2. But the trial correctly predicted significant rainfall over the London area, where the control was going for none or very little, as verified by radar. Similarly, the trial gave more medium and low level cloud (not shown) over parts of the Midlands, Wales and Southern England from T+21 to T+27. This was found to verify better against synoptic observations.

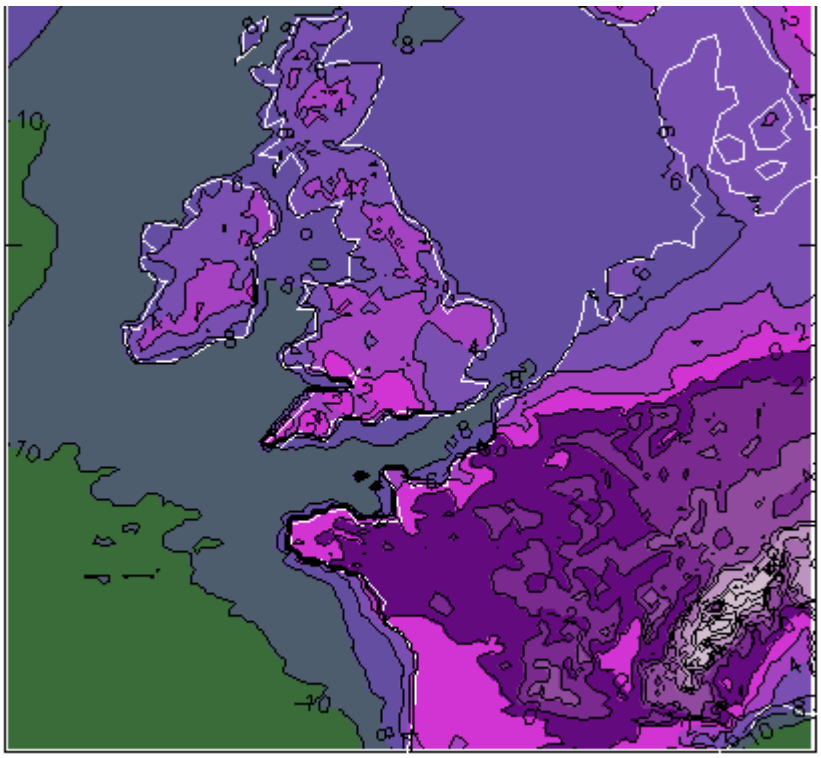


Figure 2.2.1a T+18 forecast of 1.5m temperature from the December upgrade trial, valid at 6Z 4/3/2002

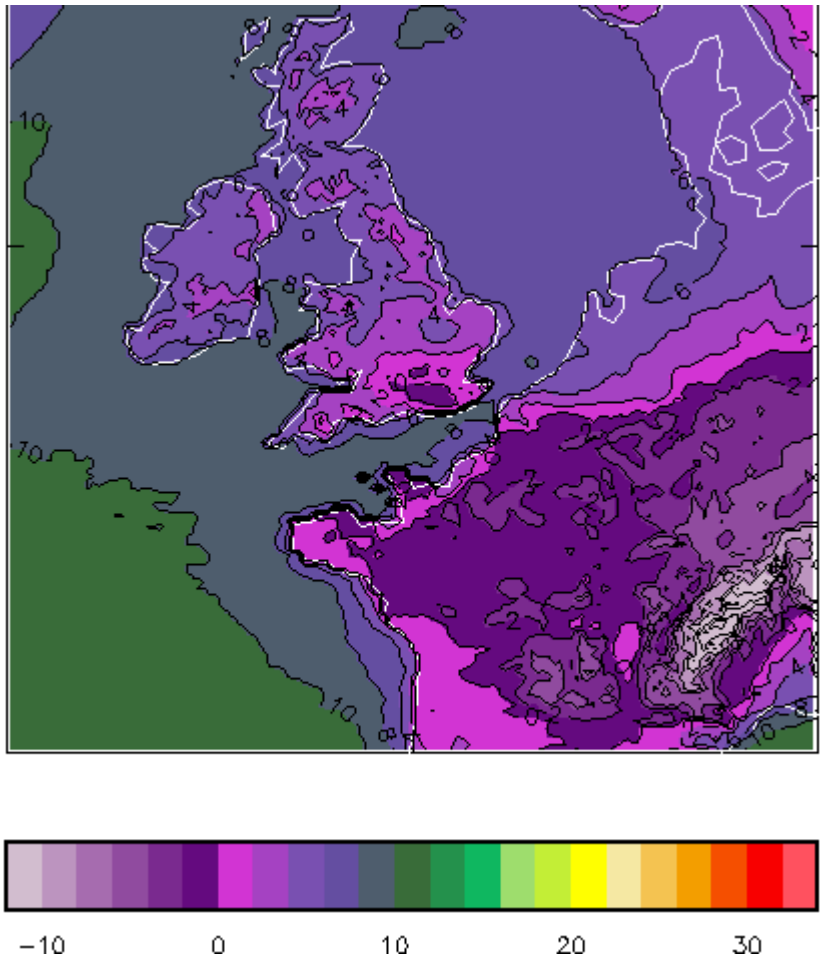


Figure 2.2.1b T+18 forecast of 1.5m temperature from the control, valid at 6Z 4/3/2002

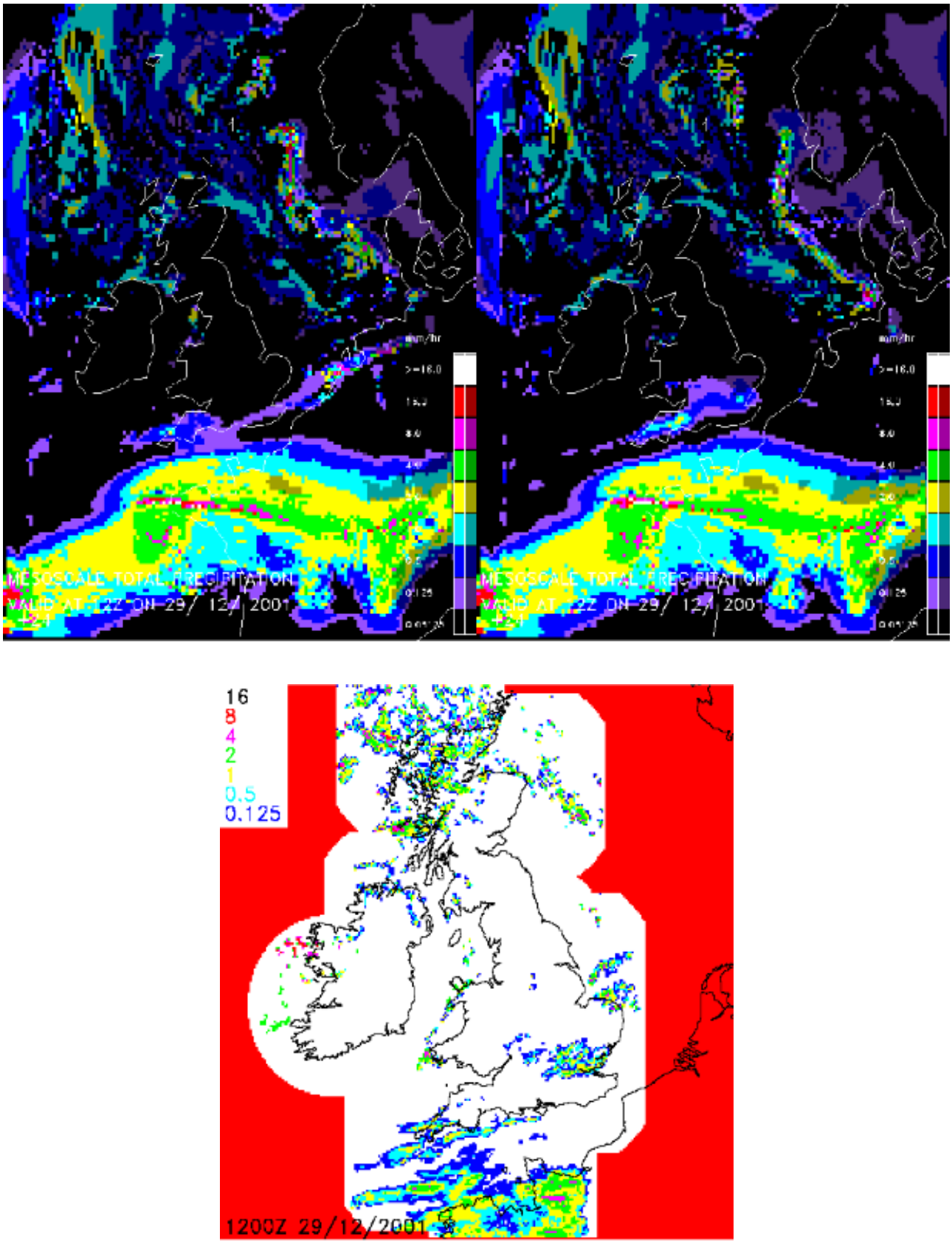


Figure 2.2.2
Topmost images show T+24 forecast precipitation fields valid at 12Z 29/12/01 for December upgrade trial (left) and control (right). Below is the radar frame for that time.

2.2.2 Objective Verification

The variables making up the 5-component UK index were verified and the results presented in Table 2.2.1 are averaged over all cases and forecast times from T+6 to T+24 as used in the index. The station list used is 'all UK stations'.

Variable	Control		Trial		Change in Skill/ETS
	rms	ETS	rms	ETS	
10-metre wind	2.906	0.750	2.880	0.754	+0.004
screen temperature	1.384	0.700	1.364	0.708	+0.008
Precipitation		0.300		0.313	+0.013
cloud		0.252		0.262	+0.010
visibility		0.101		0.114	+0.013
average 'UK index'		0.4206		0.4302	
% change in UK index for trial					+2.2%

Table 2.2.1 Summary of UK index components for the case studies

ETS scores for precipitation are uniformly better. Those for visibility are mixed but better overall. RMS errors for 10m wind and screen level temperature are better at nearly all forecast times, but worse at T+00. This is consistent with the change to the covariance statistics, producing an analysis which is not so close to the observations.

Figure 2.2.3 shows cloud cover verified against observations. RMS errors are better in the trial at all forecast times except at T+00, consistent with the MOPS cloud data being given less weight in the analysis. ETS scores (not shown) are improved from T+6 onwards, although mean bias in cloud cover is very little changed after the first six hours.

Although not part of the index, rms errors for screen level relative humidity were also improved in the trial. Surface pressure was the only variable showing a slight detriment.

Summary

Table 2.2.1 shows an estimated improvement in the UK index of 2.2%. Fit of analysis to observations is worse in the trial, consistent with the changes tested, but by T+6 the forecasts are in better agreement with the observations for all 5 components of the index.

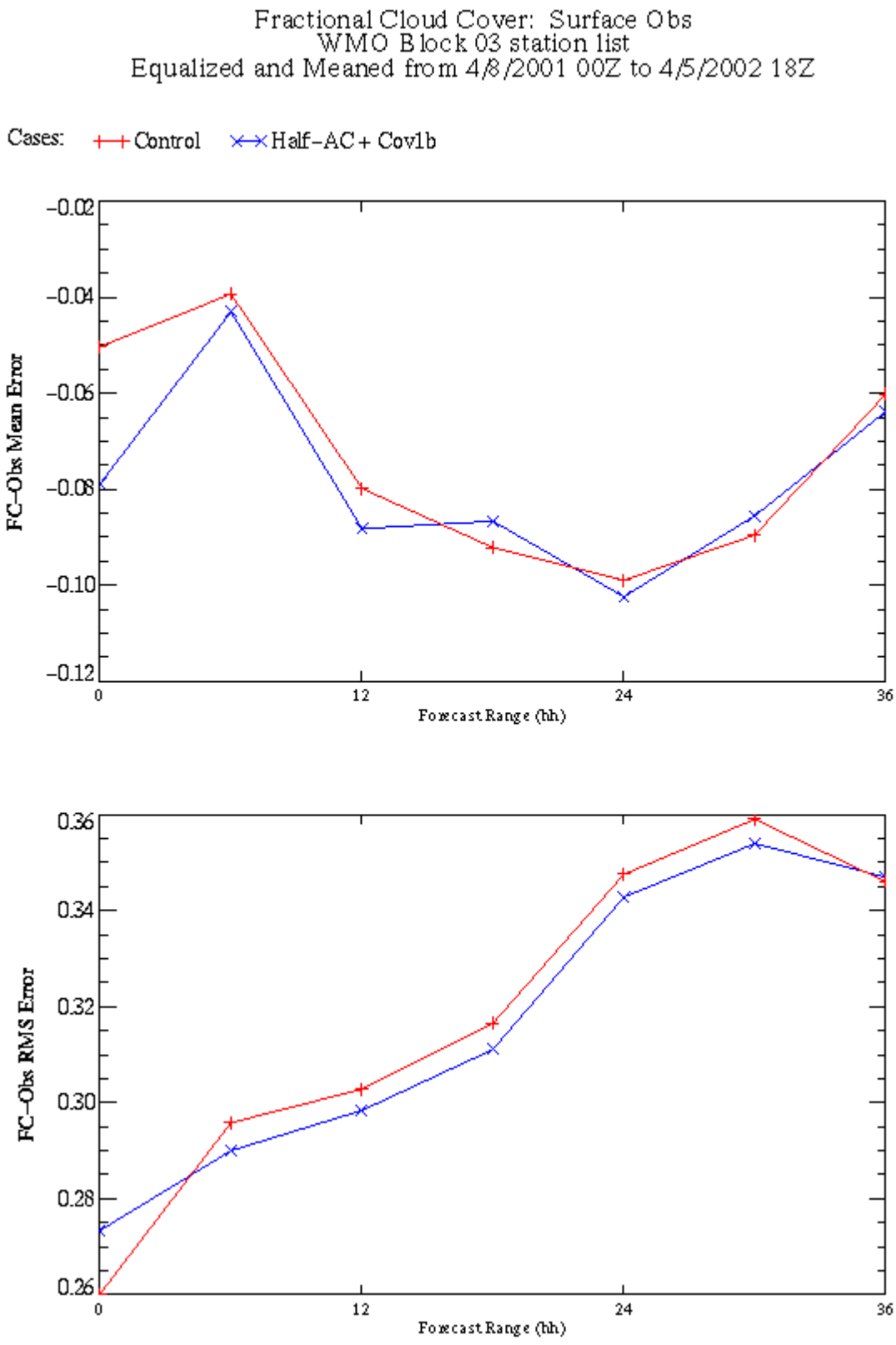


Figure 2.2.3 Total cloud cover errors v forecast time from the case studies verified at all UK stations. Upper plot is mean error, lower is rms. Control is in red, December upgrade trial in blue.

2.3 Real-time Trial

A real-time trial was run during the month of November 2002. This was primarily as a robustness test prior to operational implementation. No detailed subjective assessment was carried out, although forecasts were checked to make sure there were no major discrepancies between trial and operations. No large differences were found.

Table 2.3.1 below shows a positive impact overall on the UK index. As for the case studies, impacts in most of the variables comprising the index are negative at T+0 (as assessed by verification against observations) but turn positive from T+6 onwards. Visibility alone shows an overall negative impact in the index, but this impact is small. When all stations in the model area are included, the impact for visibility is positive.

Variable	Control		Trial		Change in Skill/ETS
	rms	ETS	rms	ETS	
10-metre wind	2.860	0.786	2.842	0.788	+0.002
screen temperature	1.453	0.695	1.442	0.700	+0.005
Precipitation		0.362		0.379	+0.017
cloud		0.223		0.226	+0.003
visibility		0.179		0.176	-0.003
average 'UK index'		0.4491		0.4538	
% change in UK index for trial					+1.06%

Table 2.3.1 Summary of UK index components for the real-time trial

Impact on precipitation, assessed using all stations in the model area, is particularly good (Figure 2.3.1).

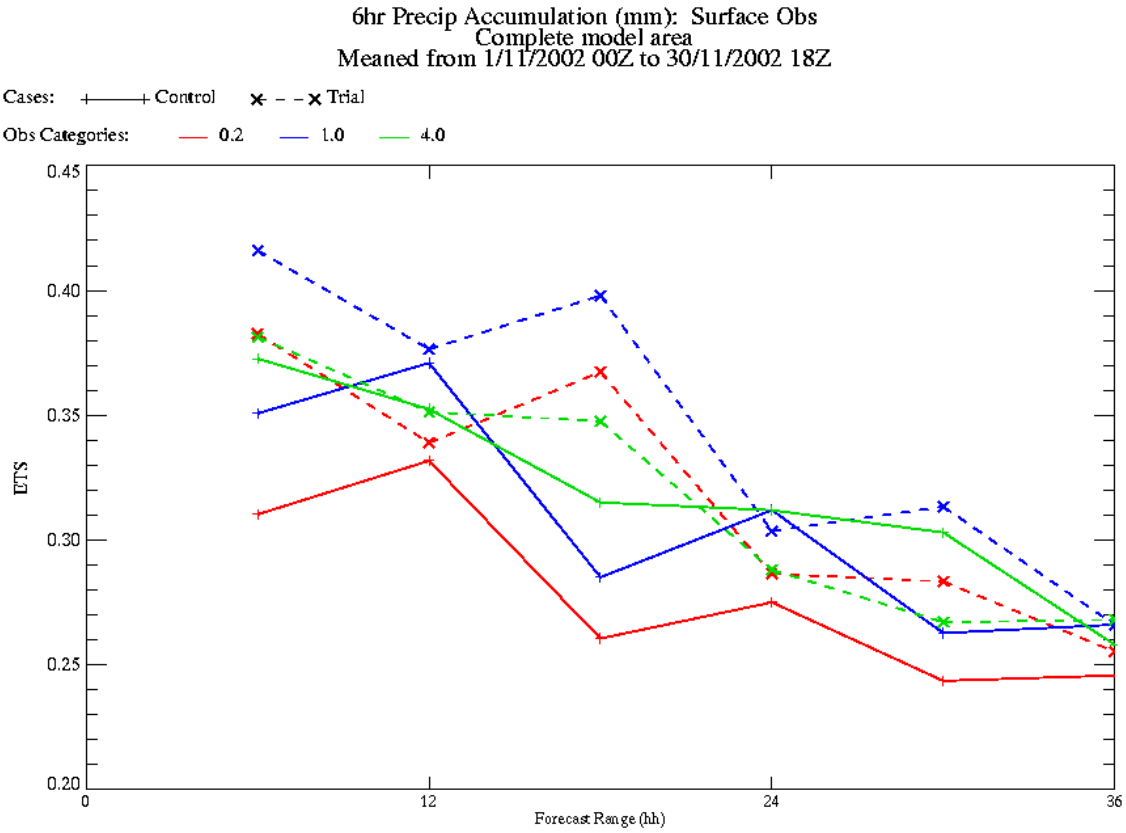


Figure 2.3.1 Precipitation ETS against forecast time for Operational (solid line) and Real-time Trial of the December upgrade (dashed line), for thresholds 0.1, 1.0, 4.0 mm/hr.

3. The March 2003 Upgrade

3.1 Introduction

3.1.1 Specification of the Upgrade Package

The components of the package were:

- revised tuning of Latent Heat Nudging (LHN) rainfall assimilation - the relaxation coefficient was halved, as was done for cloud data in the December 2002 upgrade. A tighter restriction was also placed on the maximum scaling at a point before the LHN algorithm is forced to search nearby grid points for a better matched latent heating profile. For further details, see Christidis and Macpherson (2004). The main impact of this change was to improve objective verification of the first 6-12 hours of the precipitation forecast. In tests of LHN changes alone, the 12-case impact of the reduced relaxation coefficient was +1.5% on the ETS for rainfall (+0.5% on the UK index), while the revised scaling limits gave 0.5-1.0% on the rainfall ETS (+0.1% on UK index).
- introduction of AMSU data - tests showed that when combined with retuned LHN, AMSU-A and AMSU-B data can improve rain and cloud in about half of cases and return an overall neutral impact on the UK index. For more details, see Candy et al. (2004). A couple of technical details are noted here:
    - Extraction of AMSU data is run on a single PE due to a problem which occurs in the unusual situation where the number of AMSU data is non-zero but less than the number of PEs. Along with this, to keep extra extraction costs within 2 minutes, a limit of 2000 observations has been imposed on the extraction. In most cycles, this will not imply a loss of data, but in extreme situations, up to two thirds of the data may not be assimilated. A code change will be prepared to remove this restriction in a future upgrade.
    - AMSU assimilation is currently run with the full nonlinear observation operator form with RTTOV calculations on each iteration. The cheaper double loop option may be tested in future.
- introduction of METEOSAT-6 rapid scan satellite winds - these winds are thinned prior to assimilation, and help to fill in holes in the coverage of METEOSAT-7 data. Monitoring statistics indicated they are of comparable quality to the METEOSAT-7 observations. For further detail, see the Appendix.
- analysis increment displacement correction - when analysis increments are computed at full model resolution, as operationally in the Mes, they were written out with a one grid-point eastward displacement. This correction should have a very small but systematically beneficial impact.
- Correction to stratospheric humidity - this is a correction to deal with some uninitialised values when re-setting q in the stratosphere within climatological limits.

Two further changes were prepared but for technical reasons were held over to a future upgrade in January 2004, along with a new MPP version of the OPS Extraction code.

- use of screen temperature data in mountainous regions - after a study of monitoring statistics, it was concluded that the threshold for (station-model) height, above which we reject the data, could be relaxed from 200m to 500m. Data are of course given a lapse rate correction for the height difference before use. This affects only ~10 stations in the UK.
- a vertical interpolation correction for MOPS cloud data was identified and tested. These cloud data were being interpolated to the staggered rho levels rather than the correct theta/q levels. It is expected to have only a small impact - over a subset of 5 trial cases, the UK index impact from this change alone was just -0.2% over the whole Mes area.

3.1.2 Trial

The package was tested on the same standard set of case studies used for the December upgrade. For technical convenience it ran with Var 19.1 and so did not include the increment displacement correction built into Var 19.3. Also no rapid-scan satellite winds were available at the time of these cases.

The parallel trial began on 20th February 2003, and ran until 18th March. It included the full trial package of science changes, though the rapid scan winds were only added on 24th February. The trial software versions were UM 5.3, Var 19.3 and OPS 12.4+.

3.2 Subjective assessment

3.2.1 Case study trial

All 24 forecasts for the 12 case studies were assessed against control output, with subjective comparison against the radar rain-rate and, where necessary, synoptic charts and observations. All runs were compared on 3-hourly frames for both 00Z and 12Z start times and for the following fields: Total precipitation, Pressure at mean sea level, High medium and low cloud, snow probability (where applicable), Fog probability.

Out of the 24 pairs of runs compared, 18 were found to have no significant differences in the fields examined. The 6 cases with any significant differences or preferences are described below.

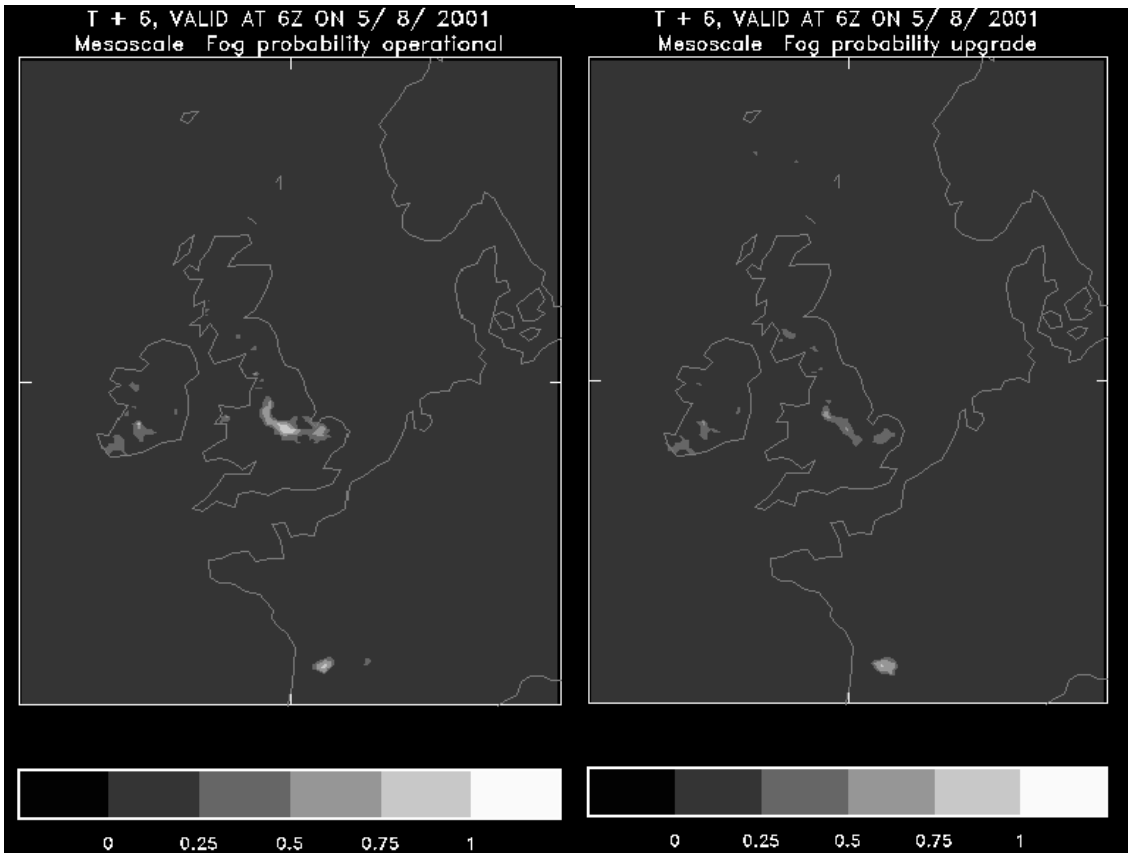
12Z 2nd May 2002 - *land-based convection*

The T+3 (15Z) trial precipitation frame alone was slightly preferred for having more shower activity over central and southeast England.

00Z 5th August 2001 - *organised summer convection*

On the T+3 and T+6 frames the trial run had a smaller area of high fog probability over the North Midlands which was preferred. Figure 3.2.1 below shows the T+6 frames, with

the verifying observations showing visibilities generally 7km or more and with only one station reporting fog.



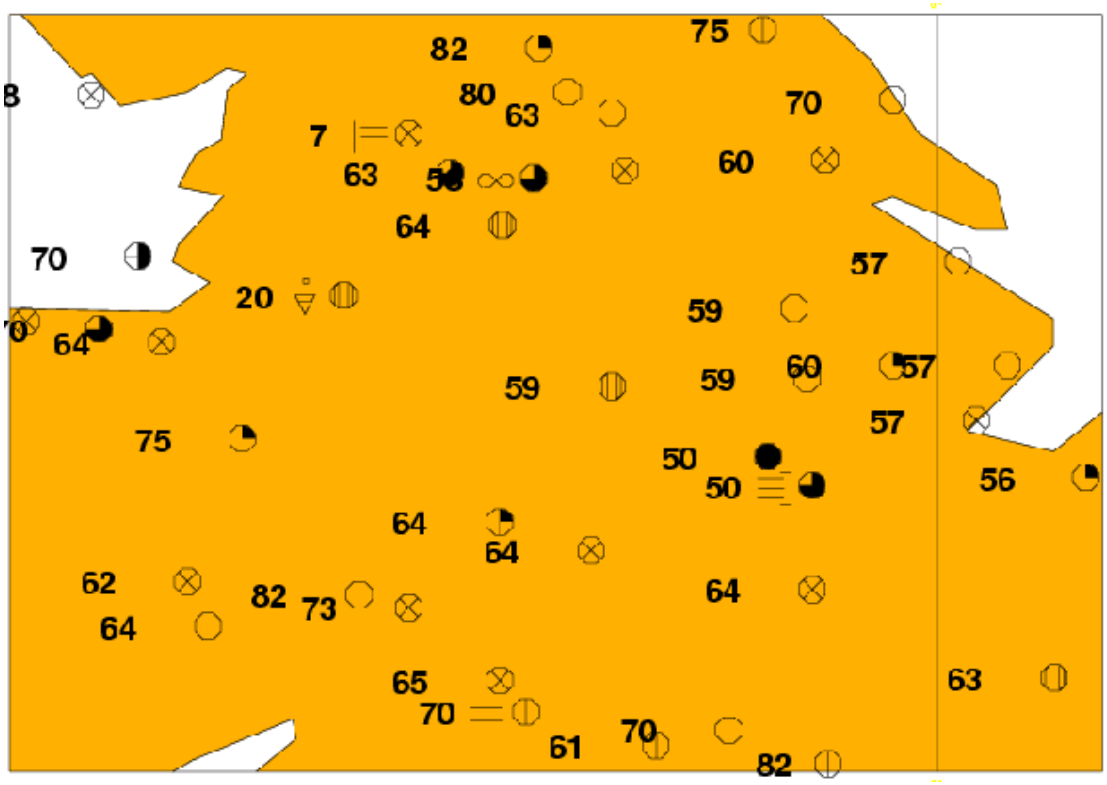
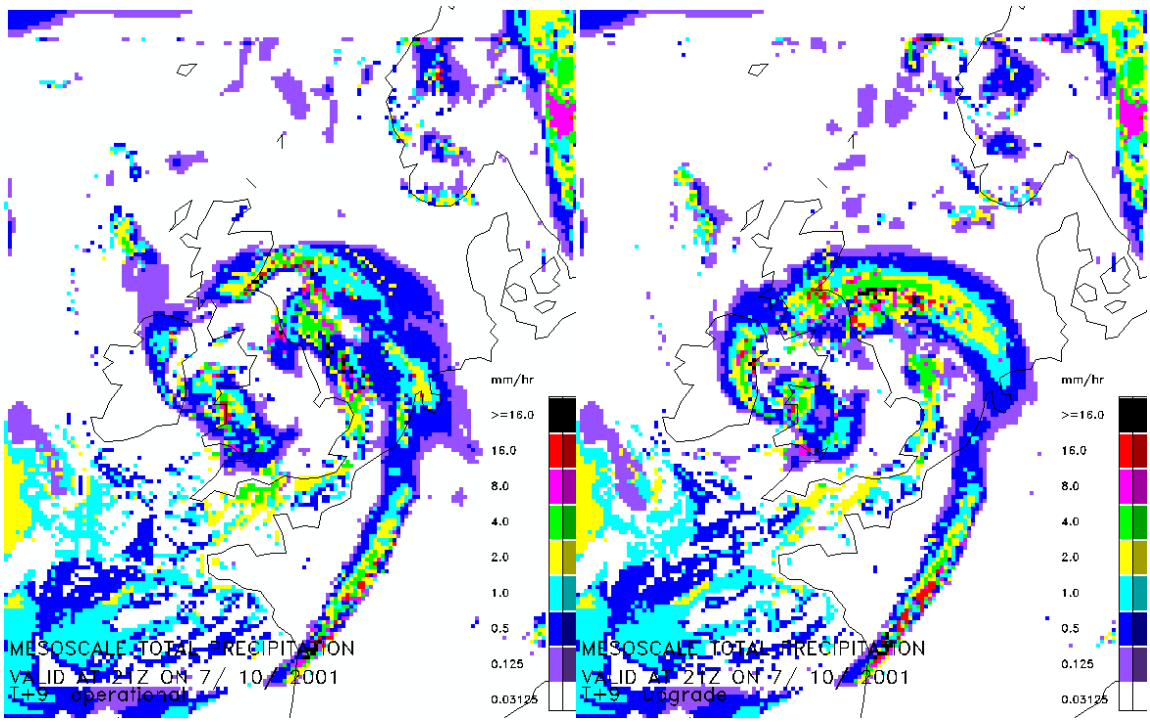


Figure 3.2.1: T+6 fog probabilities VT 6 UTC, 5/8/01. Top left for operational control and top right for trial of March 03 upgrade package. Lower panel for verifying surface observations.

12Z 7th October 2001 - *land gales*

At T+3 and T+9 the trial frames had a slightly better size and placement of a heavy rain-band. This is shown in Figure 3.2.2. PMSL frames from T+3 to T+24 all showed the trial low centre ~2hPa deeper, and on some frames approximately 10 miles further east than in the operational run. These differences were also a better fit to the observations. Figure 3.2.3 shows the T+12 frames and the verifying NMC analysis, with the trial centre correctly deeper. At this time the position of the centre was little different between the two runs.



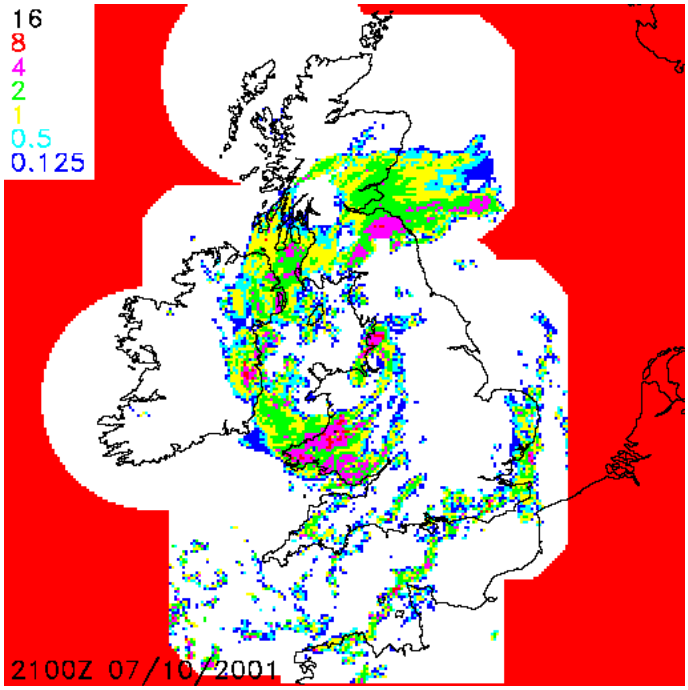


Figure 3.2.2: T+9 forecasts of precipitation rate VT 21 UTC 7/10/01. Top left for operational control, top right for trial of March 03 upgrade package and lower panel for verifying radar frame.

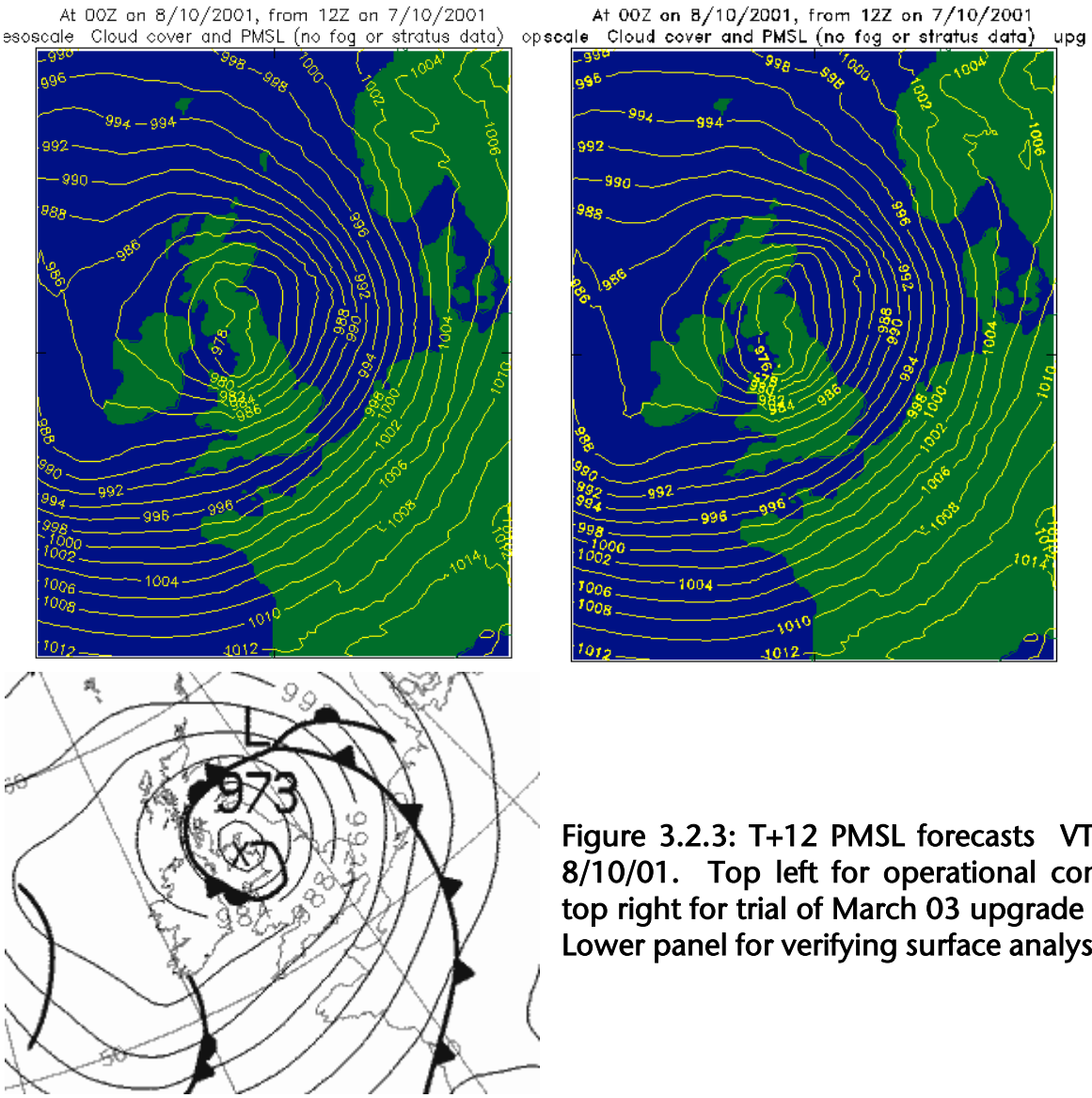


Figure 3.2.3: T+12 PMSL forecasts VT 00 UTC 8/10/01. Top left for operational control and top right for trial of March 03 upgrade package. Lower panel for verifying surface analysis.

12Z 14th October 2001 - *radiation fog*

In this run the T+0 and T+3 trial frames just had a slightly better fit to the radar precipitation.

00Z 14th October 2001 - *radiation fog*

The trial was slightly preferred for having somewhat fewer spurious showers over southern England and a narrower frontal rain-band to the northwest on the T+0 and T+6 frames. Figure 3.2.4 shows the T+0 frames and verifying radar rain-rates. The trial run also had a larger area of high fog probability, along with a considerably increased probability level, over the North Sea from T+0 to T+12, this decaying as it moved northwards to the east of Scotland. The lack of observations in the area concerned meant this could not be verified.

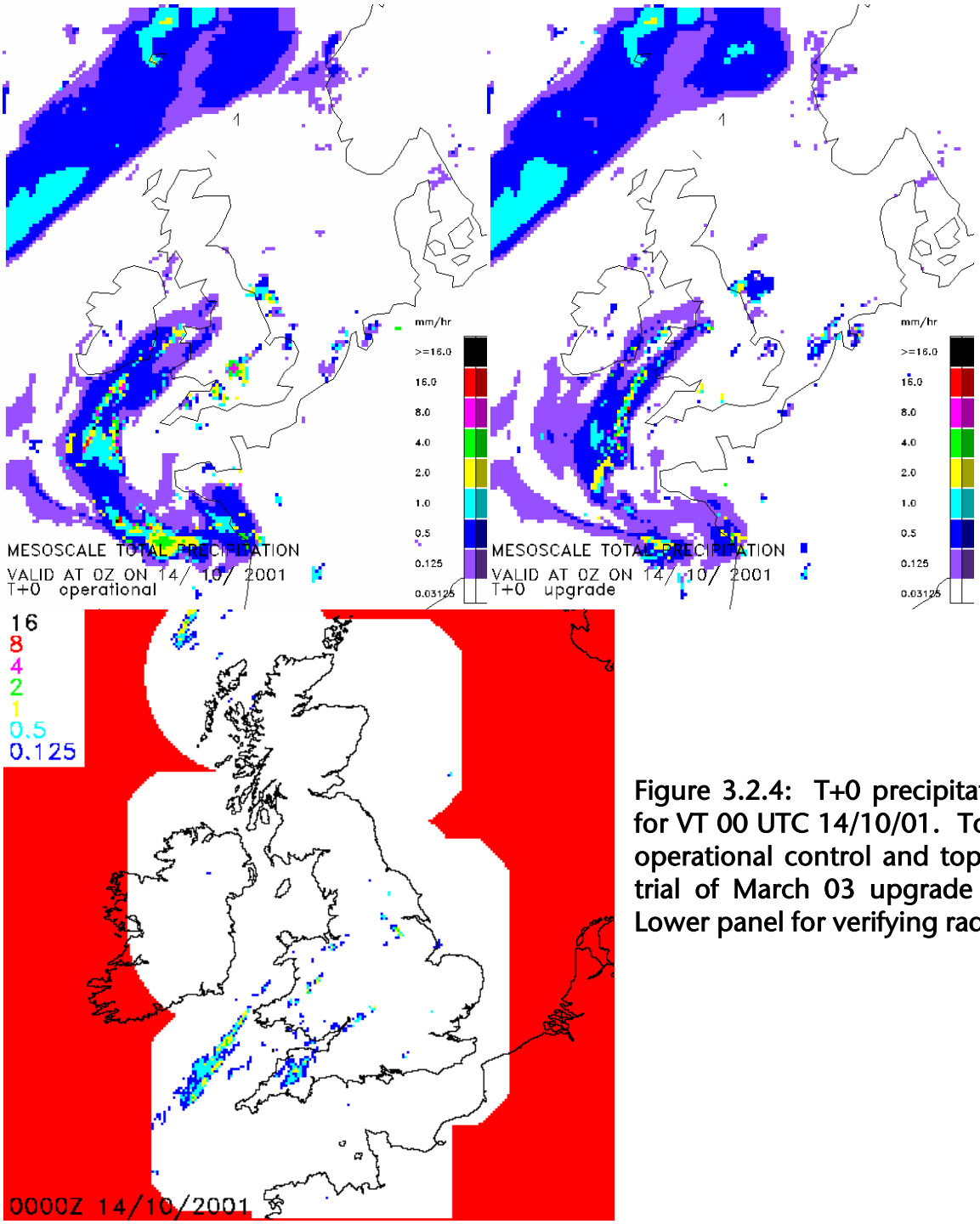


Figure 3.2.4: T+0 precipitation rates for VT 00 UTC 14/10/01. Top left for operational control and top right for trial of March 03 upgrade package. Lower panel for verifying radar frame.

12Z 28th December 2001 - *mixed snow and rain*

Precipitation in the trial was slightly preferred on frames T+24, 27 and 30 for a faster clearance of a rain/snow area SE'wards away from southern England. There were also some small differences in the medium and low cloud relating to these differences. Figure 3.2.5 shows the T+27 frames and the verifying radar.

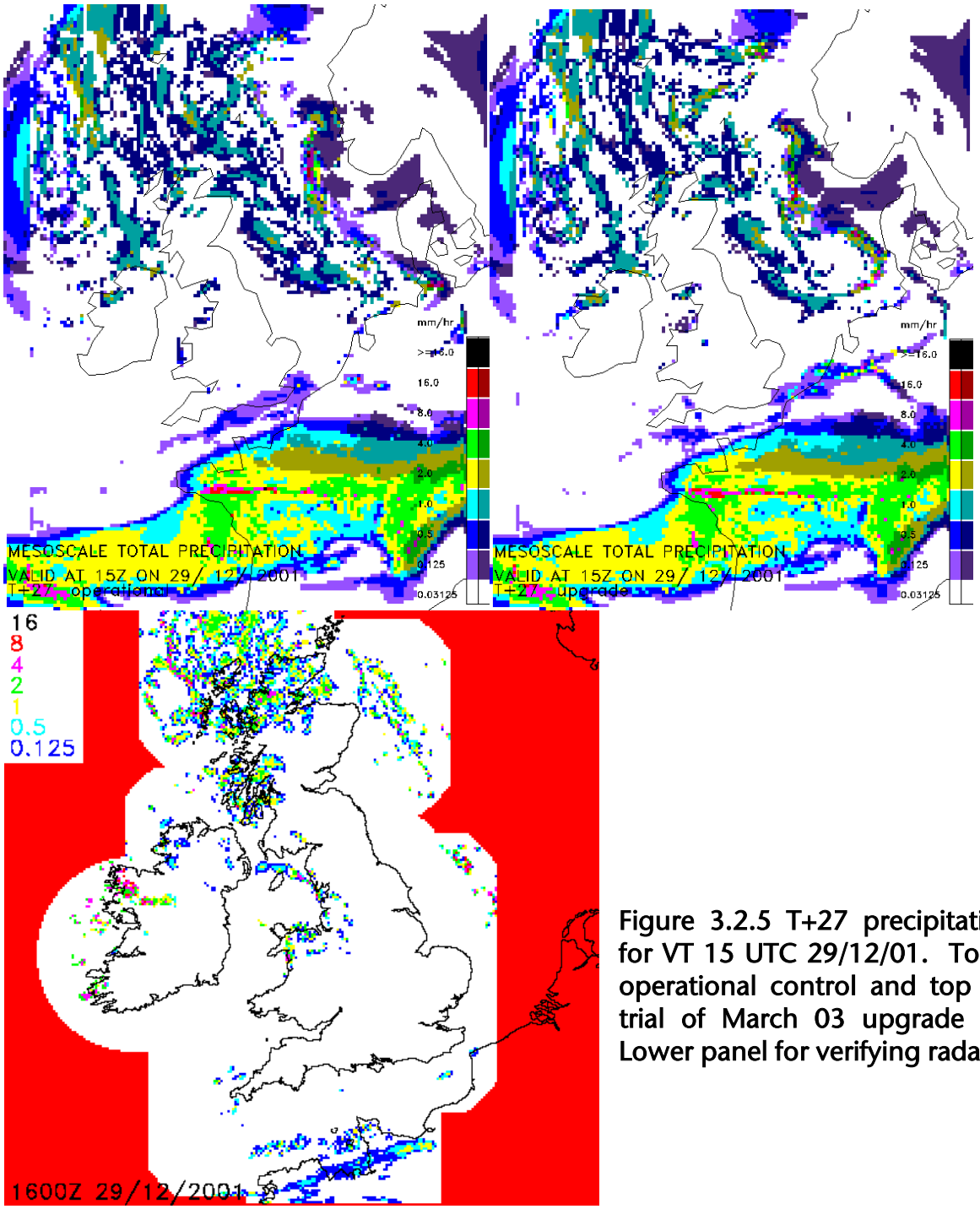


Figure 3.2.5 T+27 precipitation rates for VT 15 UTC 29/12/01. Top left for operational control and top right for trial of March 03 upgrade package. Lower panel for verifying radar frame

Summary

There were only a few differences between the control and trial runs that could be described as significant, but in all cases the trial run was preferred, albeit in most cases for only a frame or two in each forecast. No case of any significant detriment to the forecast was found.

3.2.2 Subjective assessment of the parallel runs

Only the period 19-26th February was assessed subjectively. Although the trial signal was broadly neutral, there were *some* significant differences, mainly in precipitation and PMSL, and some of these favoured the operational run, but there were a few more frames where the trial run was preferred, especially for precipitation. Figure 3.2.6 shows one of these where the trial was clearly better.

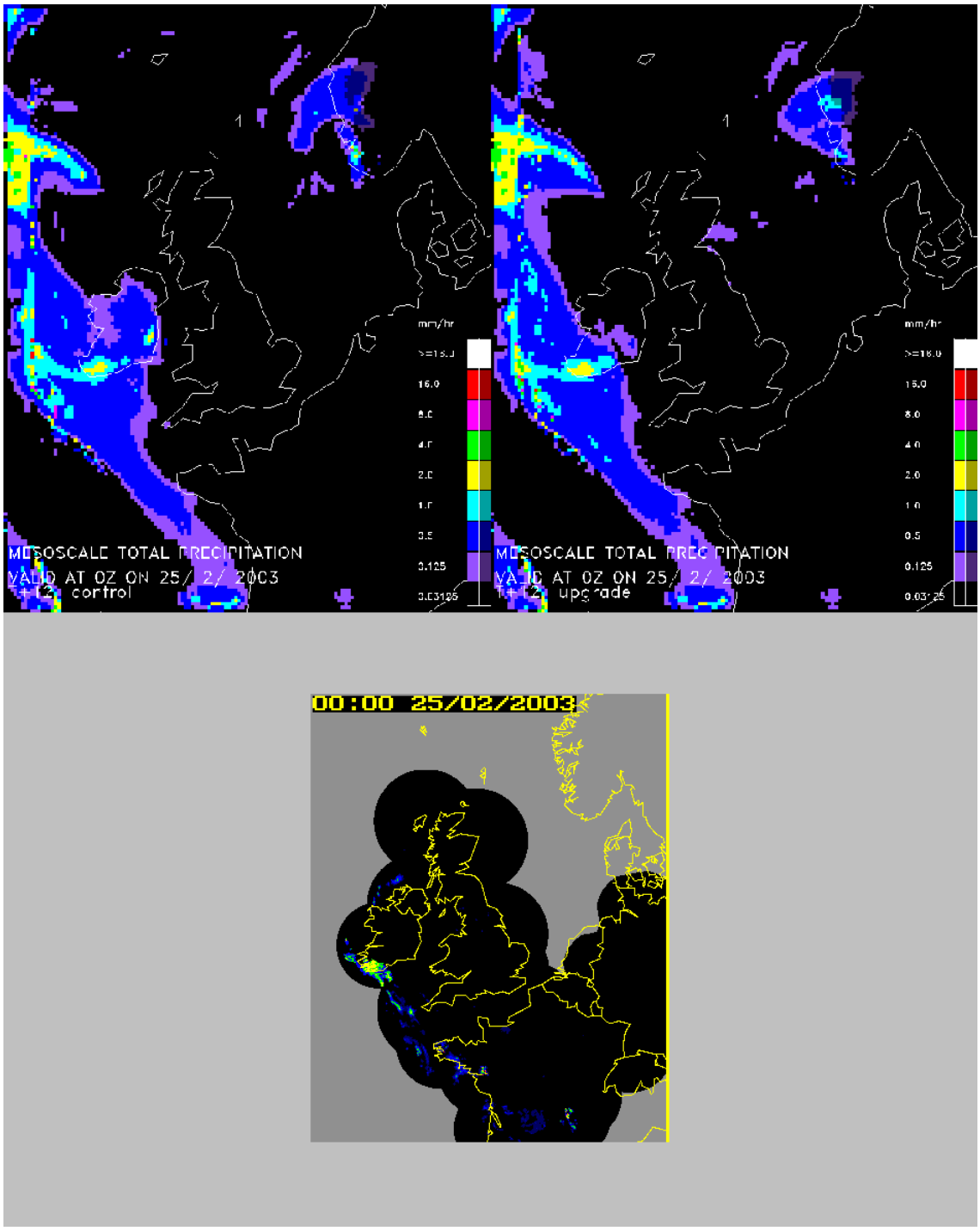


Figure 3.2.6: T+12 precipitation rates for VT 00 UTC 25/02/03. Top left for operational control and top right for trial of March 03 upgrade package. Lower panel for verifying radar frame

There was also one run, 12Z 24th Feb., with a significant difference in low cloud, fog and stratus probabilities over an area of the North Sea adjacent to the coast of northeast England on frames T+6, T+9 and T+12. Figure 3.2.7 clearly shows that the trial was better when verified against the visible imagery, time-series of which showed this stratus/fog to be quite persistent.

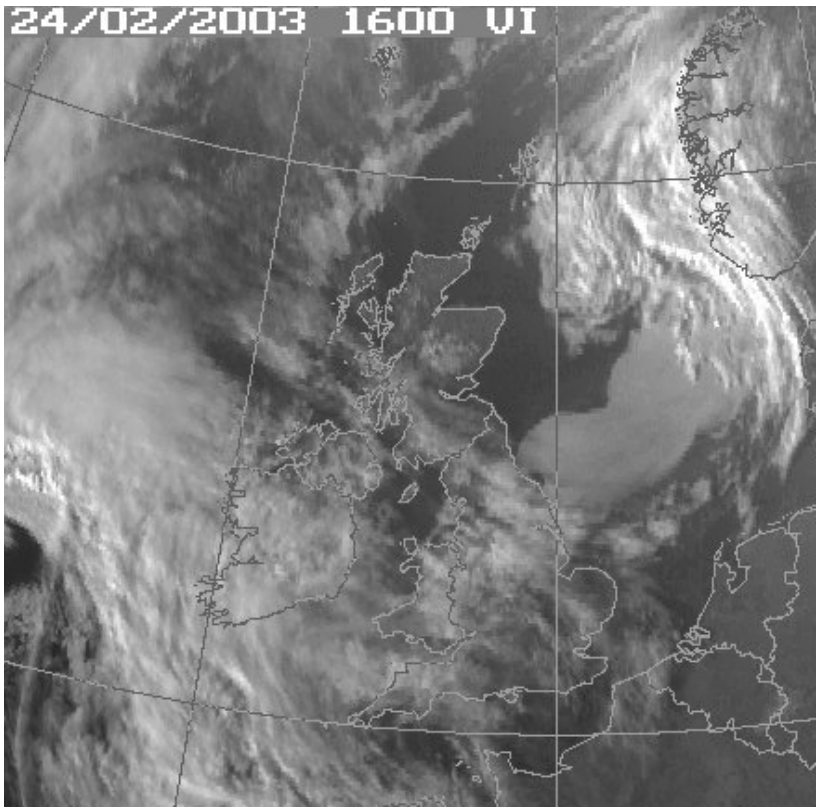


Figure 3.2.7: stratus probability at T+6, VT 18 UTC 24/2/03. Operational control (top left) and trial (top right), with visible image for 1600 UTC.

A run *with* the upgrade package but *without* AMSU data was available for comparison and this clearly showed that it was AMSU data that gave the greatest impact, with the non-AMSU run being much the same as the operational run (cf. top left of Figure 3.2.8 with top left of Figure 3.2.7). Figure 3.2.8 shows the T+6 frame of the

stratus probability and low cloud cover for these two runs.

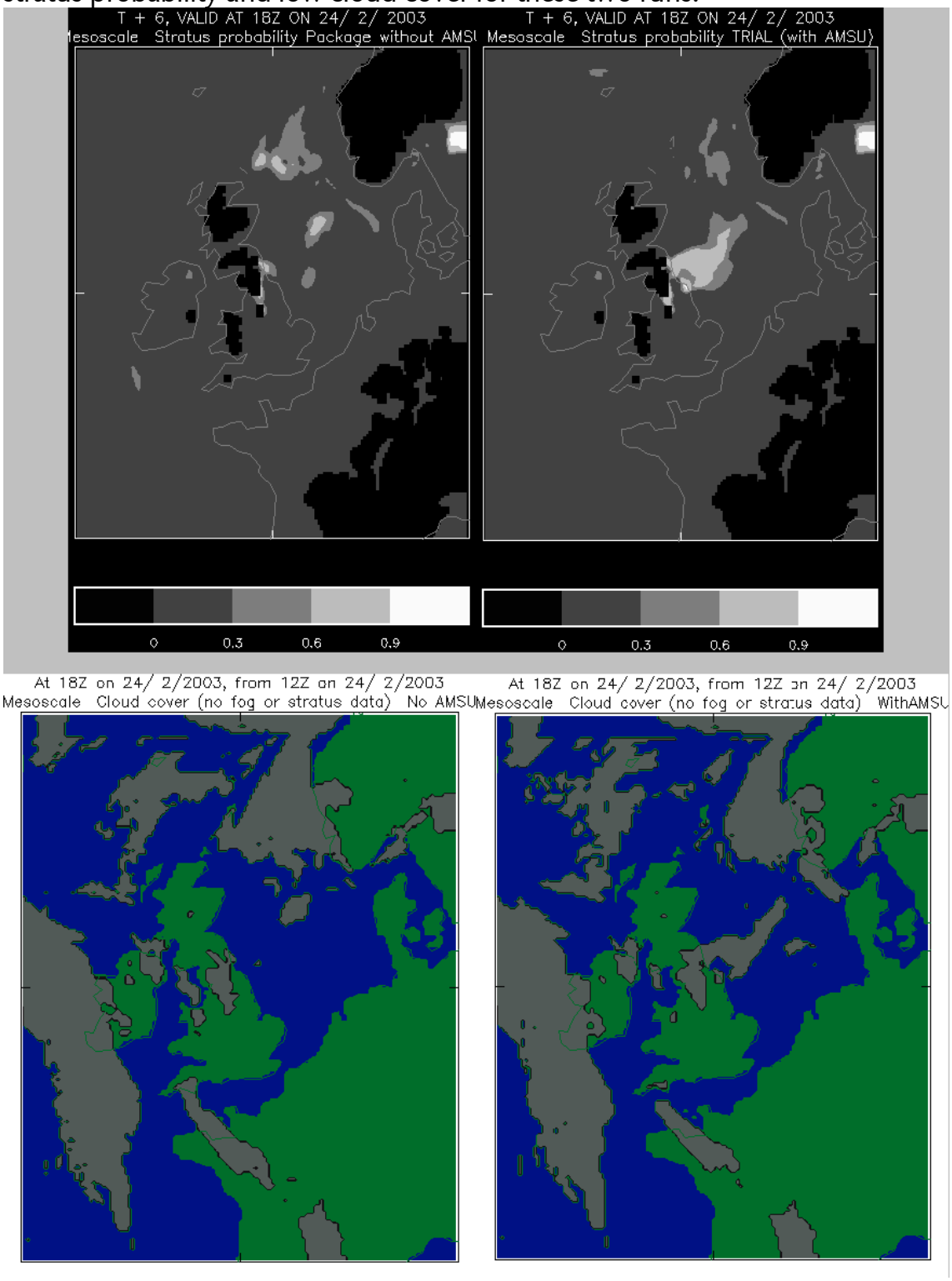


Figure 3.2.8: for same case shown in Figure 3.2.7 but for trial package without AMSU data (left) and full trial package with AMSU data (right). Stratus probability in top panels and cloud cover in lower panels.

3.3 Objective Verification

3.3.1 Case Studies

The variables making up the 5-component UK index were verified and the results presented in Table 3.1 are averaged over all cases and forecast times from T+6 to T+24, as used in the index. The station list used is 'all UK stations', which provides better sampling than the standard UK index list of only ~40 stations.

Variable	Control		Trial		Change in Skill/ETS
	rms	ETS	rms	ETS	
10-metre wind	2.88	0.750	2.87	0.753	+0.003
screen temperature	1.36	0.700	1.37	0.695	-0.005
precipitation		0.309		0.317	+0.008
cloud amount		0.260		0.257	-0.003
visibility		0.133		0.137	+0.004
average 'UK index'		0.4304		0.4317	
		%age change in UK index for trial			+0.3%

Table 3.1 - Summary of UK index components for the case studies

For *precipitation*, the verification is against 6-hourly accumulations at synop stations. For a closer look at the signals for individual thresholds and forecast times, see Figures 3.3.1 and 3.3.2. The advantage of the trial at T+6 is clear for all thresholds, and remains for the light and heavy thresholds at T+12. Beyond this, impact is more mixed.

For *cloud*, the slightly detrimental ETS signal over the UK was not found over the whole model area, where instead a slight improvement was registered.

Skill changes for *10-metre wind and screen temperature* were estimated on the basis of mean skill in the control being 0.75 for wind and 0.70 for temperature. For temperature, there is a very slight increase in rms error at T+12 and beyond. In terms of bias, the trial verifies very slightly warmer than the control (and drier in terms of screen RH). For *wind*, the trial has a very marginal advantage in the first 6 hours.

For *visibility*, the scores are derived from a single contingency table per threshold, collating events at all forecast times. This is a more stable way to get an average figure than averaging the ETS values from separate tables for each forecast time at each threshold. (The reason for this is that some forecast times have few low visibility events and may give unreasonable contributions to an average which gives equal weight to each forecast time.) Even so, for this variable, the slight improvement in the trial is not reliably different from neutral. Results for the whole model area were neutral.

Though PMSL is not part of the UK index, scores showed very slightly lower rms errors in the trial for the UK area.

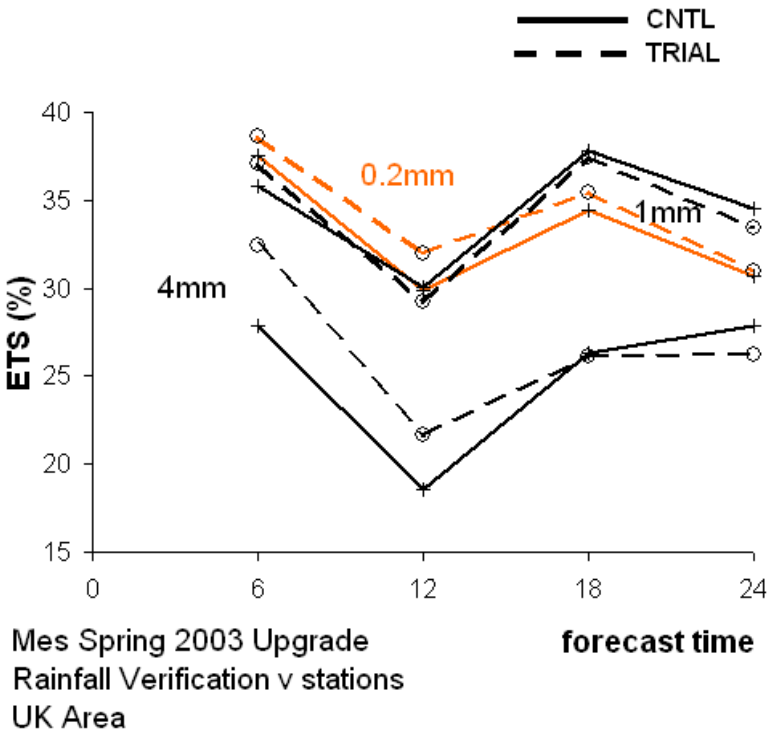


Figure 3.3.1: ETS v forecast time for 6-hourly accumulations from the case studies verified at all UK stations, for thresholds of 0.2, 1 and 4mm/6 hours.

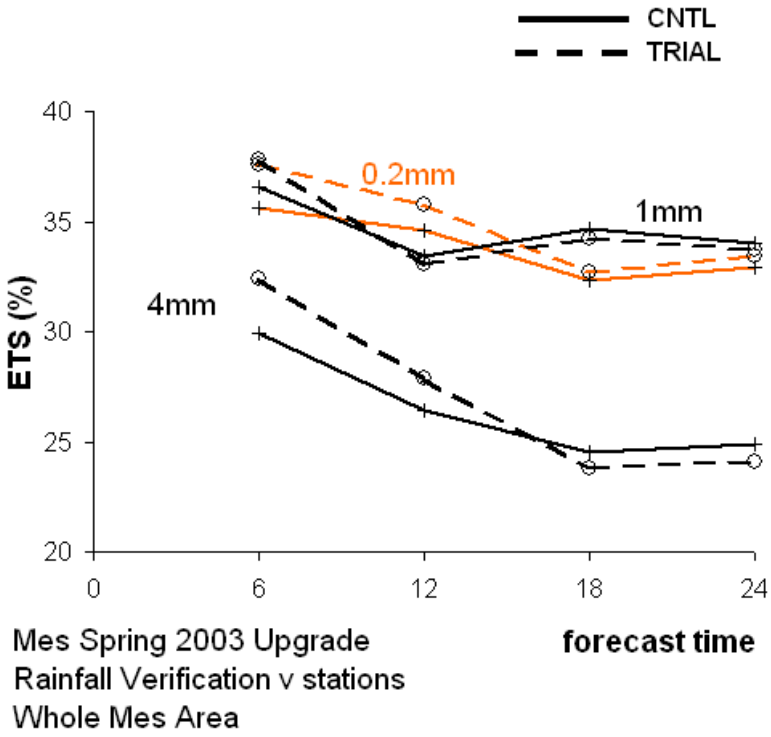


Figure 3.3.2: as Figure 3.3.1 for whole Mes area

Summary
Table 3.1 shows an estimated UK Index impact of just +0.3%, (+0.4% was obtained when verifying over the whole model area), small enough to be consistent with a neutral signal overall. Within this, however, there is evidence of a benefit for precipitation early in the forecast.

3.3.2 Parallel Trial

The variables making up the 5-component UK index were verified and the results are presented in Table 3.2. The station list used is again 'all UK stations', and there were 42 forecast verified over the 28 day period of the trial.

Variable	Control ETS/skill	Trial ETS/skill	Change in Skill/ETS
10-metre wind	0.759	0.758	-0.001
screen temperature	0.660	0.665	+0.005
precipitation	0.342	0.351	+0.009
cloud amount	0.282	0.293	+0.011
visibility	0.122	0.130	+0.008
average 'UK index'	0.4331	0.4392	
	%age change in UK index for trial		+1.4%

Table 3.2 - Summary of UK index components for the parallel trial

All variables except wind show a slight improvement in the trial. For precipitation, the improvement was mainly at T+6 and T+12, as in the case studies. For cloud, the improved trial ETS was reflected in lower rms errors for cloud fraction, albeit with a slightly larger negative bias (Figure 3.3.3).The signals for the whole Mes area were similar, with an improvement in every variable (smallest for visibility and wind) and an overall advantage of +0.8% in UK index.

3.4 Summary of verification for March 2003 upgrade package

Overall *objective verification of the case studies* gives a 0.3% increase in the estimate of the 5-component UK index for the trial, with a larger benefit in the early part of the rainfall forecast. In *subjective assessment of the case studies*, there were few occurrences of significant differences between control and trial chart output, but where differences were found, the trial was judged better. The *objective verification of the real-time trial to date shows* a trial 5-component UK index that is +1.4% with respect to the control run, again with larger benefit in the early part of the rainfall forecast and a small improvement in all variables. In *subjective assessment of the real-time trial*, the first week gave a signal that is broadly neutral but with a slight advantage to the trial in precipitation.

Taking the real-time and case study phases together, *the overall signal from the trial package* is best described as slightly positive, with evidence of benefit in short period rainfall.

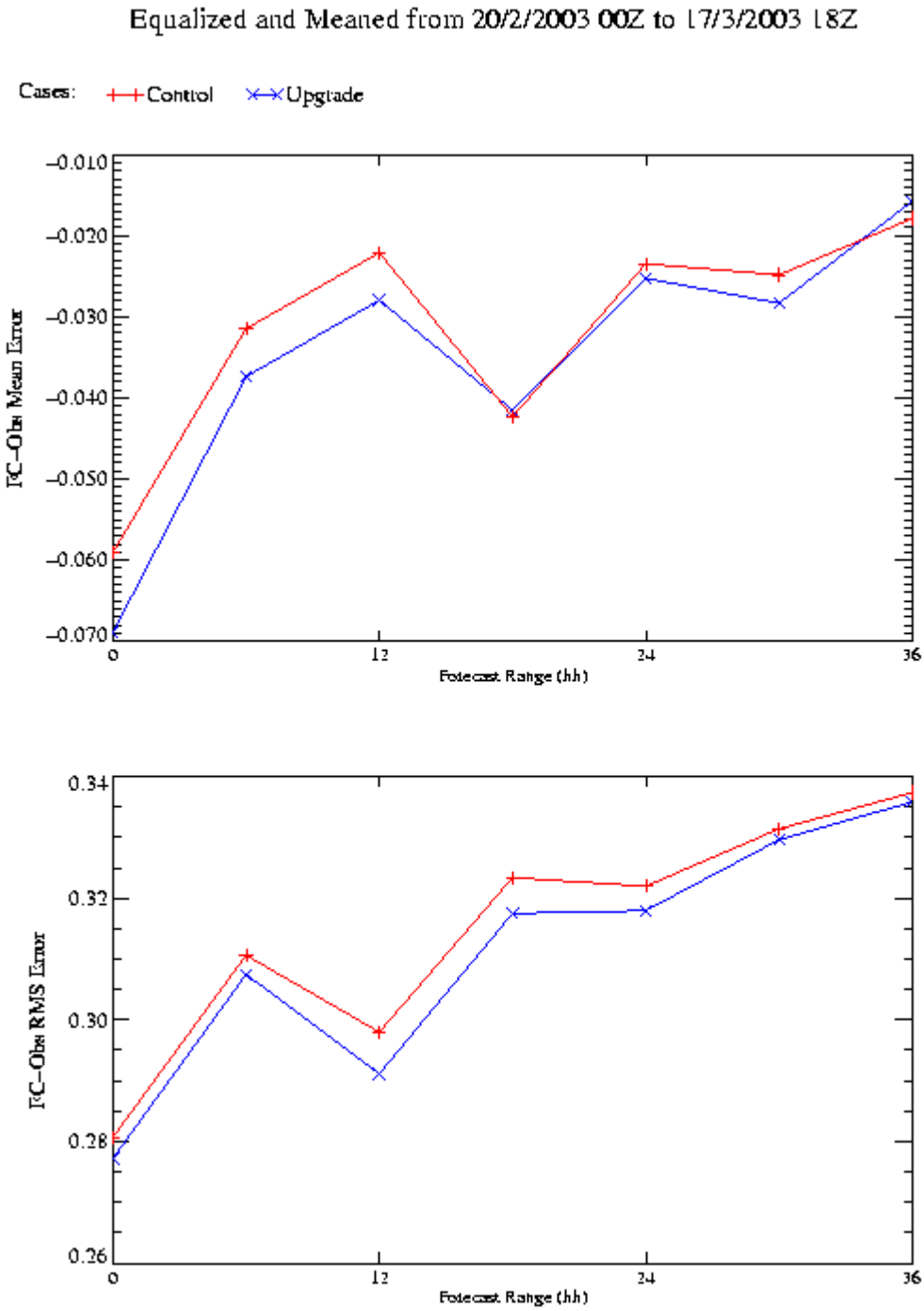


Figure 3.3.3: Cloud fraction verification at UK stations from the parallel trial for the March 2003 upgrade. Top panel for mean error and lower panel for rms error. The control is in red and the trial in blue.

4. Summary

The package introduced on 4th December 2002 was a retuning of the background error covariance statistics used within Var and of the use of MOPS cloud in the AC scheme. In both cases the retuning acts to give smaller increments.

Subjective assessment of tests of the December package on a set of case studies showed overall little synoptic impact. There were two cases though where the package gave better forecasts of cloud cover, and this benefited other aspects of the forecasts.

Objective assessment showed improvements for all components of the UK index, with an estimated increase of 2.25% in the index. Precipitation in particular scored better. Other variables gave a worse fit to observations at T+0, explained by the analysis no longer fitting the observations so closely. From T+6 onwards fit to observations was improved.

The real-time trial gave a similar though smaller signal in the verification statistics. Overall the index was improved by 1%. Subjectively there were no major differences seen.

The package introduced on 18th March 2003 had several components, of which the most significant were retuned rainfall assimilation, and the introduction of AMSU data.

Overall *objective verification of the case studies* gives a 0.3% increase in the estimate of the 5-component UK index for the trial, with a larger benefit in the early part of the rainfall forecast. In *subjective assessment of the case studies*, there were few occurrences of significant differences between control and trial chart output, but where differences were found, the trial was judged better.

The *objective verification of the real-time trial* gave a trial 5-component UK index that was +1.4% with respect to the control run. In *subjective assessment of the real-time trial*, the signal was broadly neutral but with a slight advantage to the trial in precipitation.

Taking the real-time and case study phases of the March upgrade together, the overall signal is best described as marginally positive, with evidence of benefit in short period rainfall.

Although not part of this upgrade, it is worth mentioning that a new version of *the Nimrod cloud top height program* was also implemented in March 2003. This is expected to reduce the incidence of spurious convection triggered by low level moisture wrongly assigned to a higher level, a problem of significant concern to forecasters. For further details, see Moseley (2003).

Appendix

Assimilation of Meteosat-6 rapid scan winds in the Mesoscale Model

Background

Winds derived from the standard 30 minute interval Meteosat-7 infra-red, visible and cloudy water vapour imagery have been routinely assimilated in the Mes. Since May 2002, wind vectors have also been produced in the Mes region from the 10 minute interval Meteosat-6 rapid scan imagery.

There are three main reasons to consider assimilating the Meteosat-6 rapid scan winds. Firstly, various studies have shown that the quality of visible, infrared and cloudy water vapour winds should improve with the shorter time intervals that result from rapid scanning. Secondly, the increased temporal frequency of the rapid scan winds may provide better data coverage over the Mes region. Thirdly, if a problem was to affect the Meteosat-7 satellite, there would still be satellite wind data available.

Plots of the satwind data coverage in the Mes region do show some improvement with the additional assimilation of Meteosat-6 rapid scan winds (see Figure A.1 below).

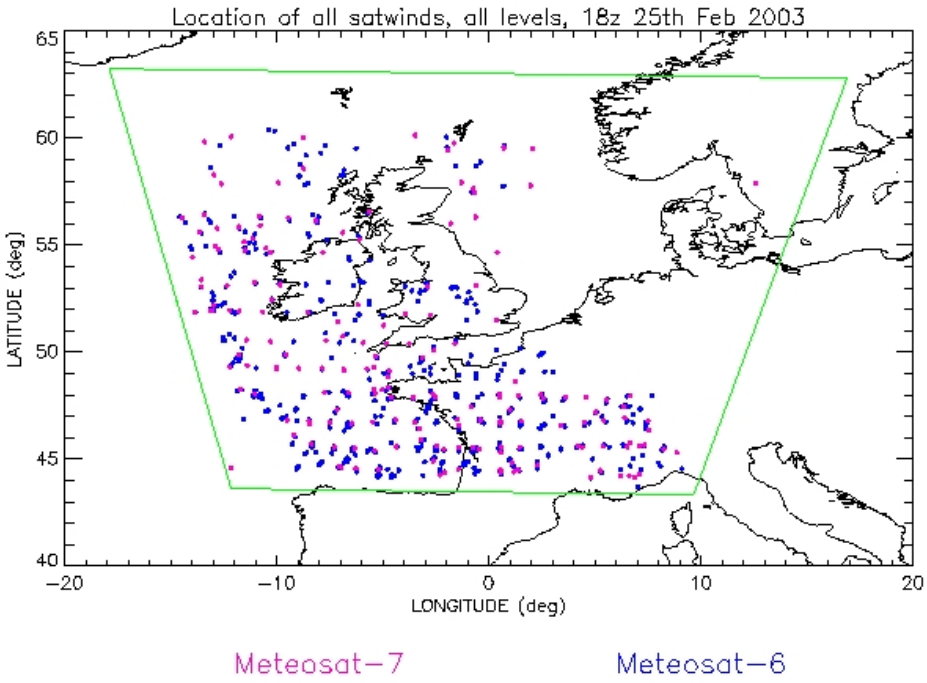


Figure A.1 *A plot showing the location of all Meteosat-6 and Meteosat-7 winds available for the 18z run on the 25th February 2003 (time window 16:30-19:29). Typically there are about 3x more Meteosat-6 winds than Meteosat-7 winds, reflecting their increased temporal resolution (30 minutes rather than 90 minutes).*

Some tests were carried out in the Met Office to check whether the rapid scan winds are of higher quality. Despite the experience of researchers at CIMSS and EUMETSAT (e.g. de Smet, 2002), a comparison of the observation-background statistics actually shows consistently slightly poorer statistics (biases and root mean square vector differences) for the Meteosat-6 rapid scan winds compared to the Meteosat-7 normal-scan winds. Rms vector wind differences are of order 5-10% larger. There are two possible explanations for this. One is that the rapid scan winds are of lower quality, possibly due to the use of a

derivation system that has been optimized for longer interval imagery. Alternatively, the rapid scan winds may be of the same or better quality, but the statistics are misleading. There are several possible reasons for this. For example, the shorter interval used for the rapid scan winds may lead to more variability in the winds, which may compare less well with a smooth background field. Despite this unexpected result, the winds are still of a sufficiently good quality and compare well to the Meteosat-7 winds when plotted. Based on these results the decision was taken to assimilate Meteosat-6 rapid scan winds in the Mes March 03 upgrade assimilation trial.

Method

In the assimilation trial, the Meteosat-6 winds are thinned together with the Meteosat-7 winds, selecting the wind with the highest quality indicator in a 1 degree / 1 degree / 100 hPa box. This thinning scale was chosen so as to remove any nearly duplicated winds without losing too much detail in the observations. Nearly duplicate winds may arise due to the same cloud being traced in the imagery from both satellites, potentially by more than one channel and at more than one time. It is also particularly important to thin the satwind data as they are known to have spatially and temporally correlated errors (e.g. Bormann et al., 2002), which are not accounted for by the assimilation system. An additional advantage is that thinning should minimize the impact of the Metosat-6 data outages, which occur for a few days every month.

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